

Carbon Capture and Sequestration in ASEAN: An Industry Perspective

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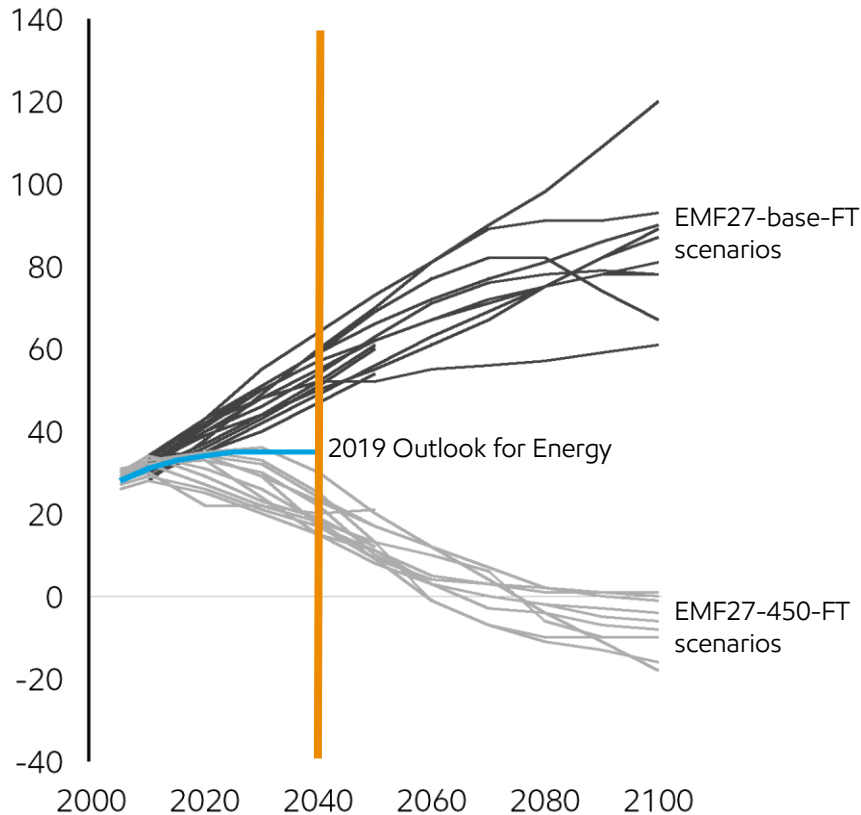
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Carbon Capture and Sequestration Required in 2°C Scenarios

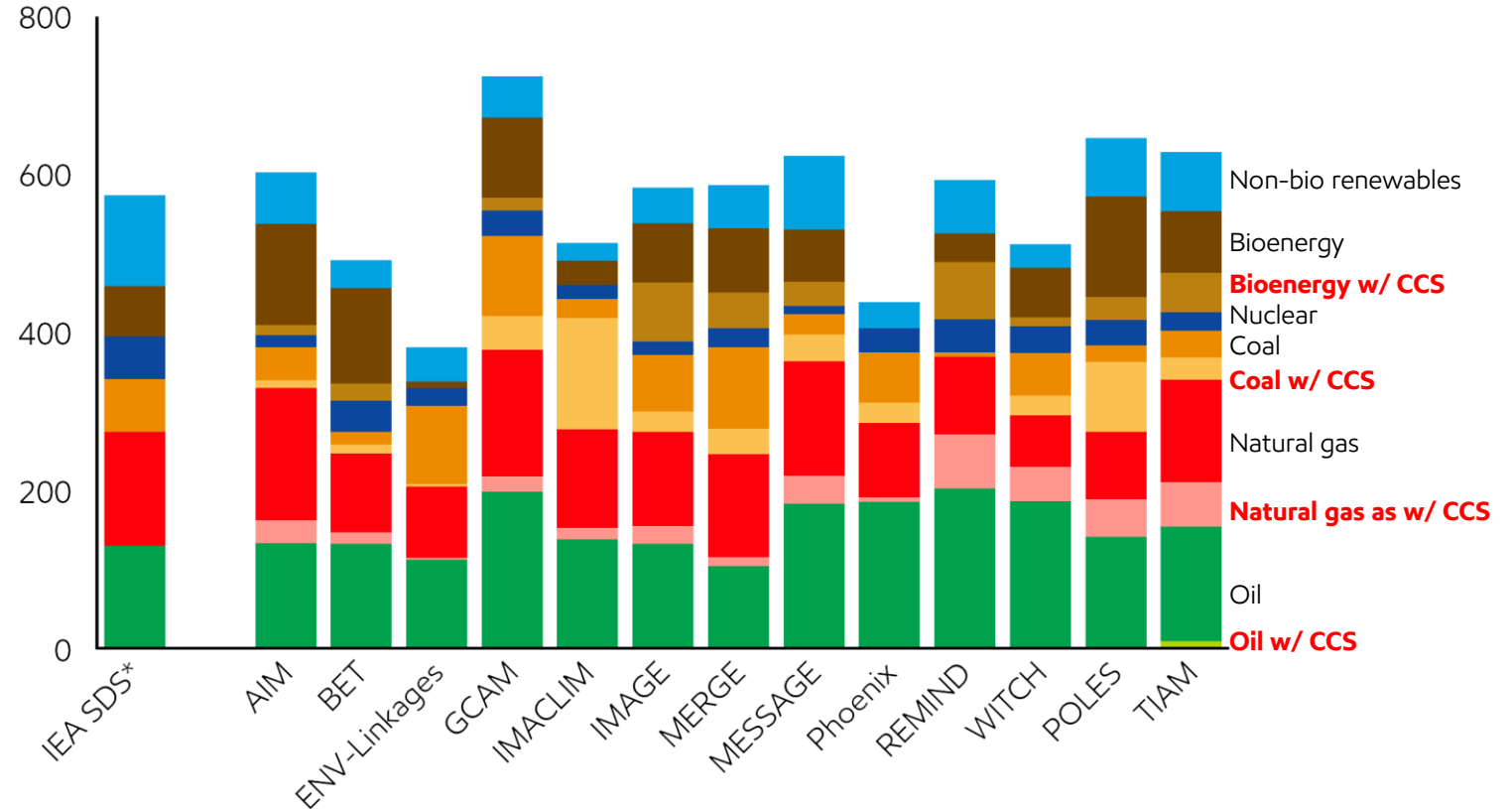
Global energy-related CO₂ emissions

Billion tonnes



2040 global demand by energy type from assessed 2°C scenarios

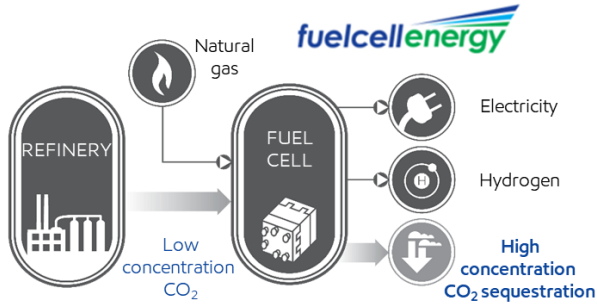
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EMF27 full technology scenarios data downloaded from: <https://secure.iiasa.ac.at/web-apps/ene/AR5DB>

*IEA WEO 2018 SDS includes CCS but breakdown by energy type is not readily identifiable

ExxonMobil Focus on CCS R&D with Partners

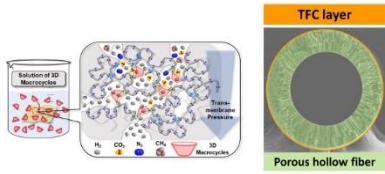


- Progressing design of carbonate fuel cell for CO₂ capture at Rotterdam refinery
 - Joint development with FuelCell Energy
 - Demonstration of technology, supplying data to inform commercial-scale developments
- Collaborating with partners on novel, high capacity materials
 - Combine ExxonMobil's materials and process expertise with external innovators
- Advancing additional CCS technology-to-scale collaborations
 - Multiple technologies via energy centers and national laboratories
 - Direct air capture with Global Thermostat
- Evaluating regional sequestration options for Singapore/ASEAN through the Singapore Energy Centre



Singapore Energy Center – Example CCUS R&D Projects

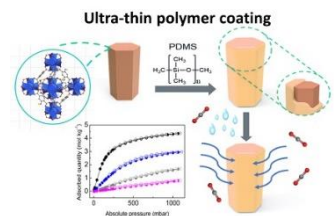
Core Research Projects



Novel membranes for hydrogen separation and CO₂ capture. NUS.



CCU using incineration bottom ash and seawater desalination brine wastes. NTU.



Develop Moisture-Resistant MOFs for CO₂ Capture. NUS.

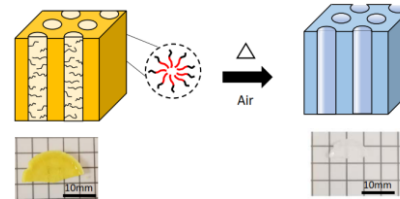
From SgEC website:

<https://sgec.sg/coreprojects/year-2019/>

ExxonMobil Collaborative Topics



Develop Steam stable COFs for CO₂ capture. NUS.

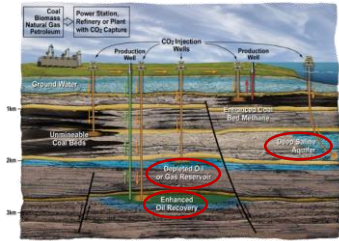


Develop Hierarchical porous materials for CO₂ capture. NTU.



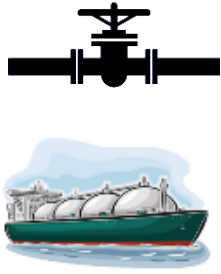
Develop regional geologic CO₂ sequestration options with subsurface, transport, and policy risks. NUS.

Regional CCS Study to Develop a Quantitative Understanding of Geologic CO₂ Sequestration Options for ASEAN



Geo-sequestration storage

- Identify and quantitatively evaluate subsurface CO₂ storage capacity
- Estimate costs of CO₂ storage



Transportation options, costs

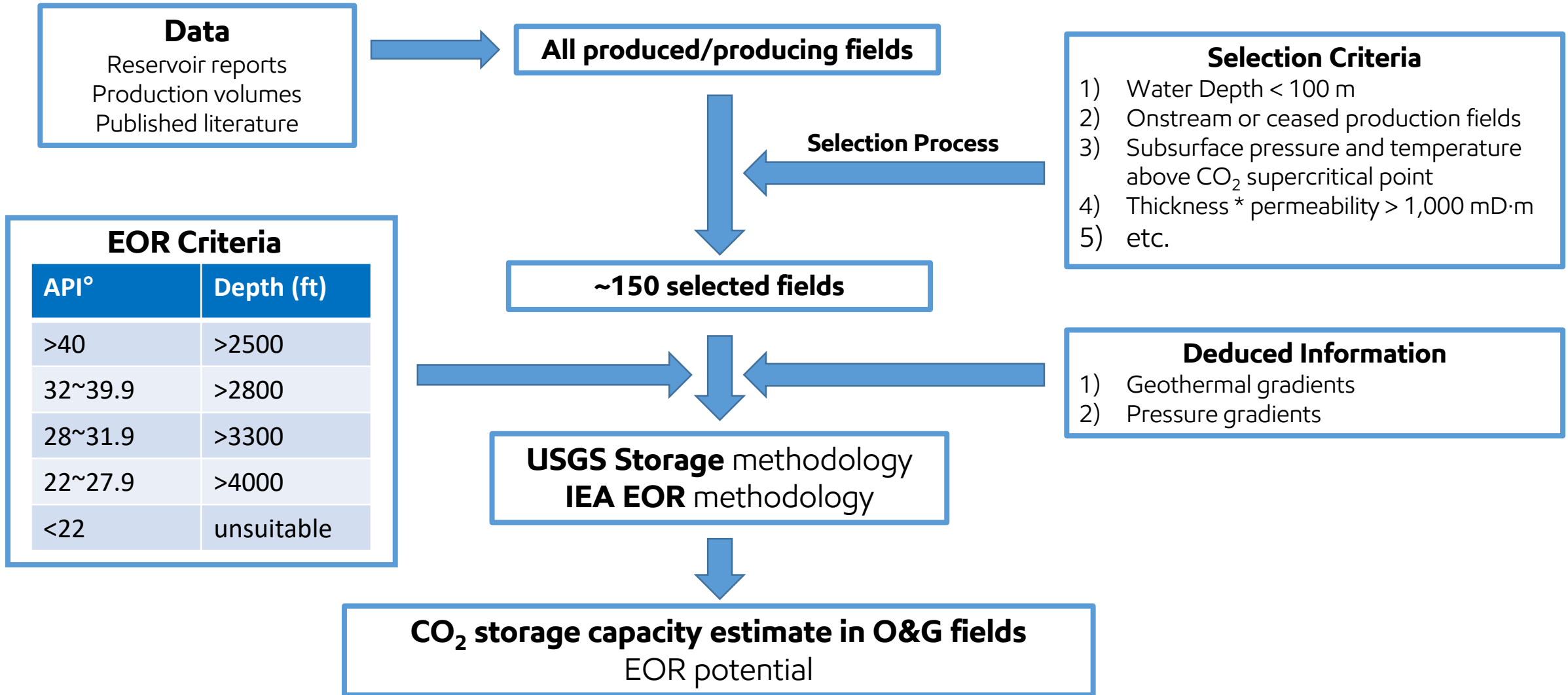
- Transport via pipeline or ship
- Estimate costs of transportation using existing and new infrastructure



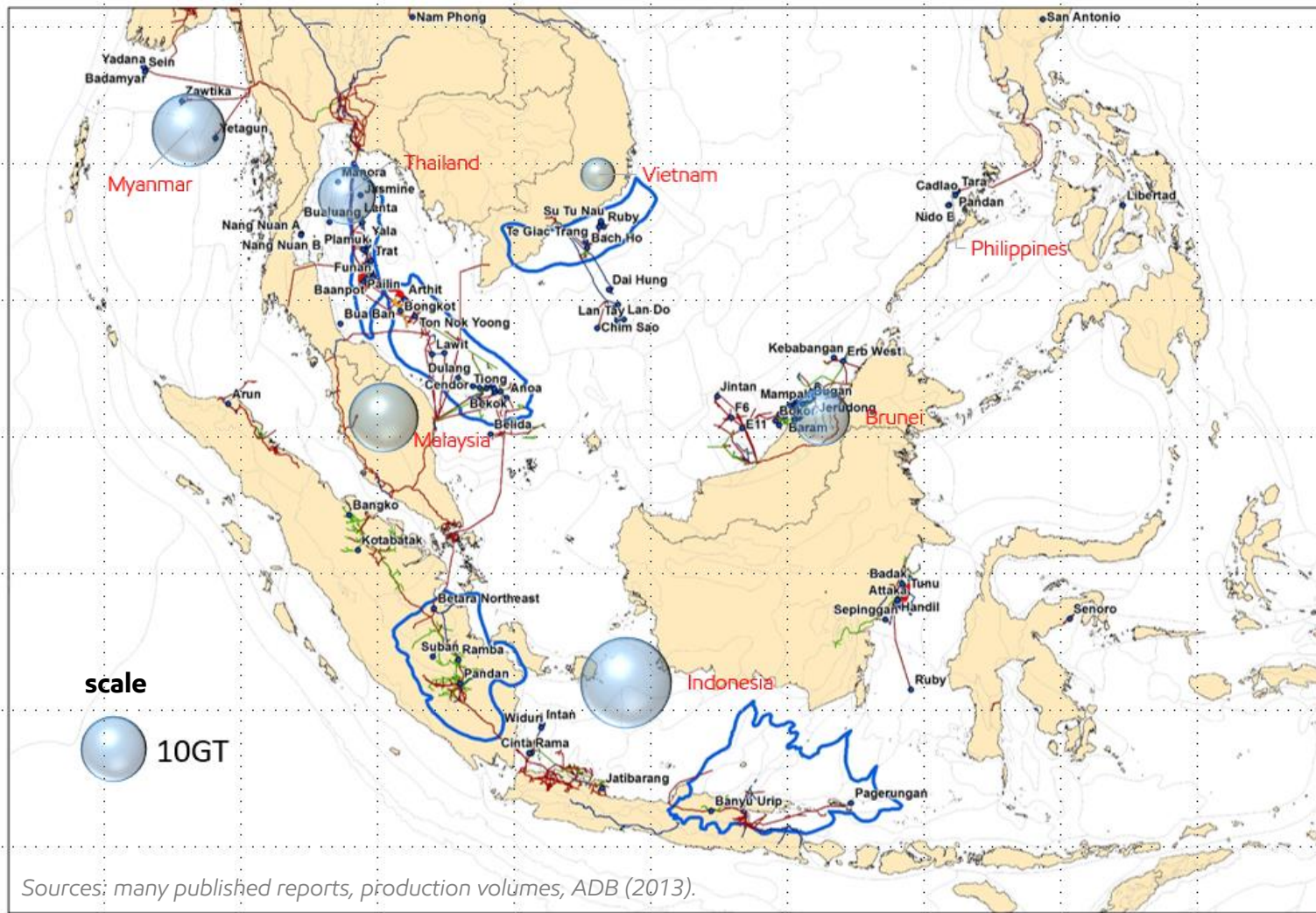
Policy, Regulation, and Incentives

- Understand current ASEAN policies that may enable significant CO₂ sequestration capacity
- Identify how ASEAN countries could establish policies and regulatory framework to allow CO₂ to be sequestered in an economical manner

Regional CO₂ Storage Capacity: Workflow



Regional CO₂ Initial Storage Capacity Estimates in O&G Fields



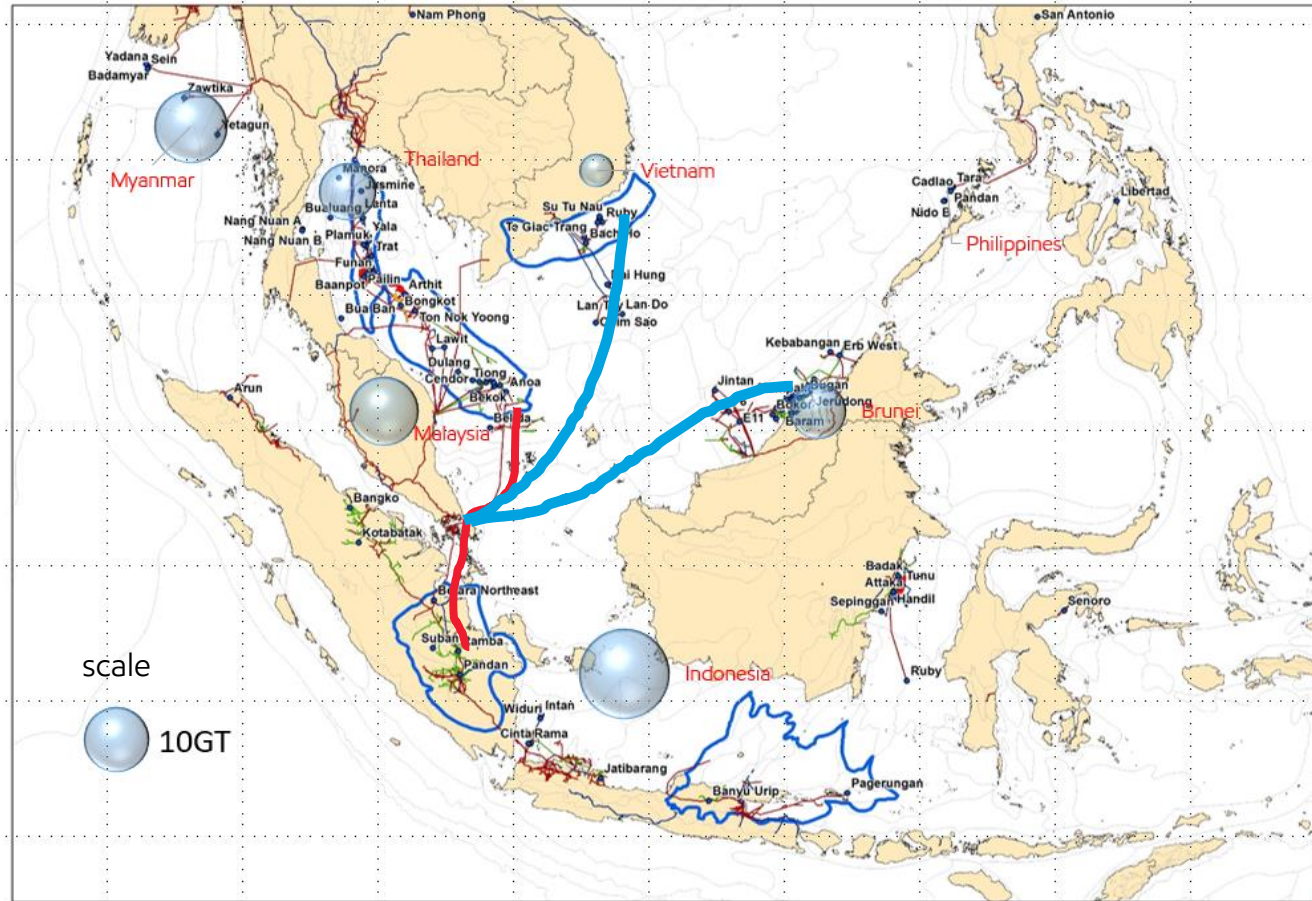
Country	2018 Emissions (2018 Million Metric Tonnes*)
Brunei	7
Myanmar	33
Indonesia	469
Malaysia	211
Philippines	126
Singapore	47
Thailand	244
Viet Nam	191
Total	1328

* Source: www.iea.org

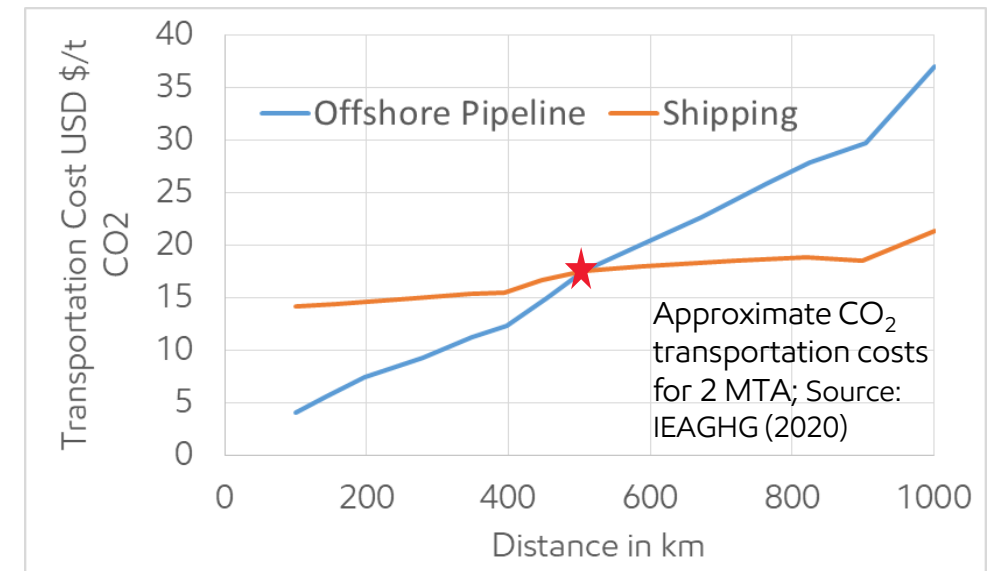
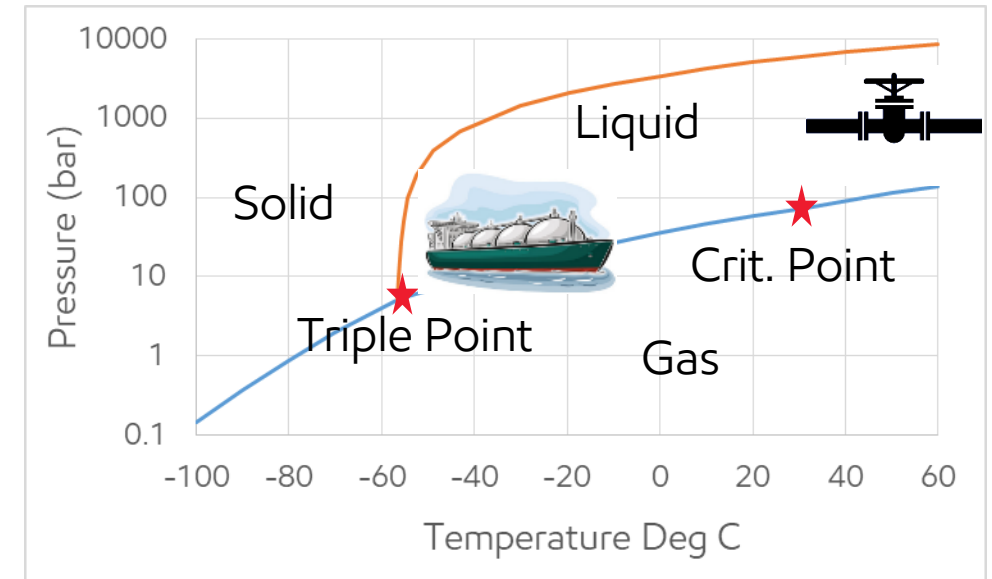
- Total storage capacity in O&G fields alone is 60 GT (CO₂ storage capacity in saline formations is not included)
- Capacity estimates based on the available data

- Storage capacity is sufficient for all

ASEAN Regional CO₂ Transportation



Typical CO₂ Transportation Routes (Pipelines and Ships)



Summary

- Carbon Capture and Sequestration (CCS) will play a significant role in mitigation of greenhouse gases worldwide as well as in ASEAN region
- ASEAN region has sufficient subsurface storage capacity to safely sequester its CO₂ emissions
- Pipelines and shipping technologies are available or will be available soon to facilitate individual CCS projects or regional hubs
- Singapore could play an active role to kick start CCS activity for whole ASEAN region

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